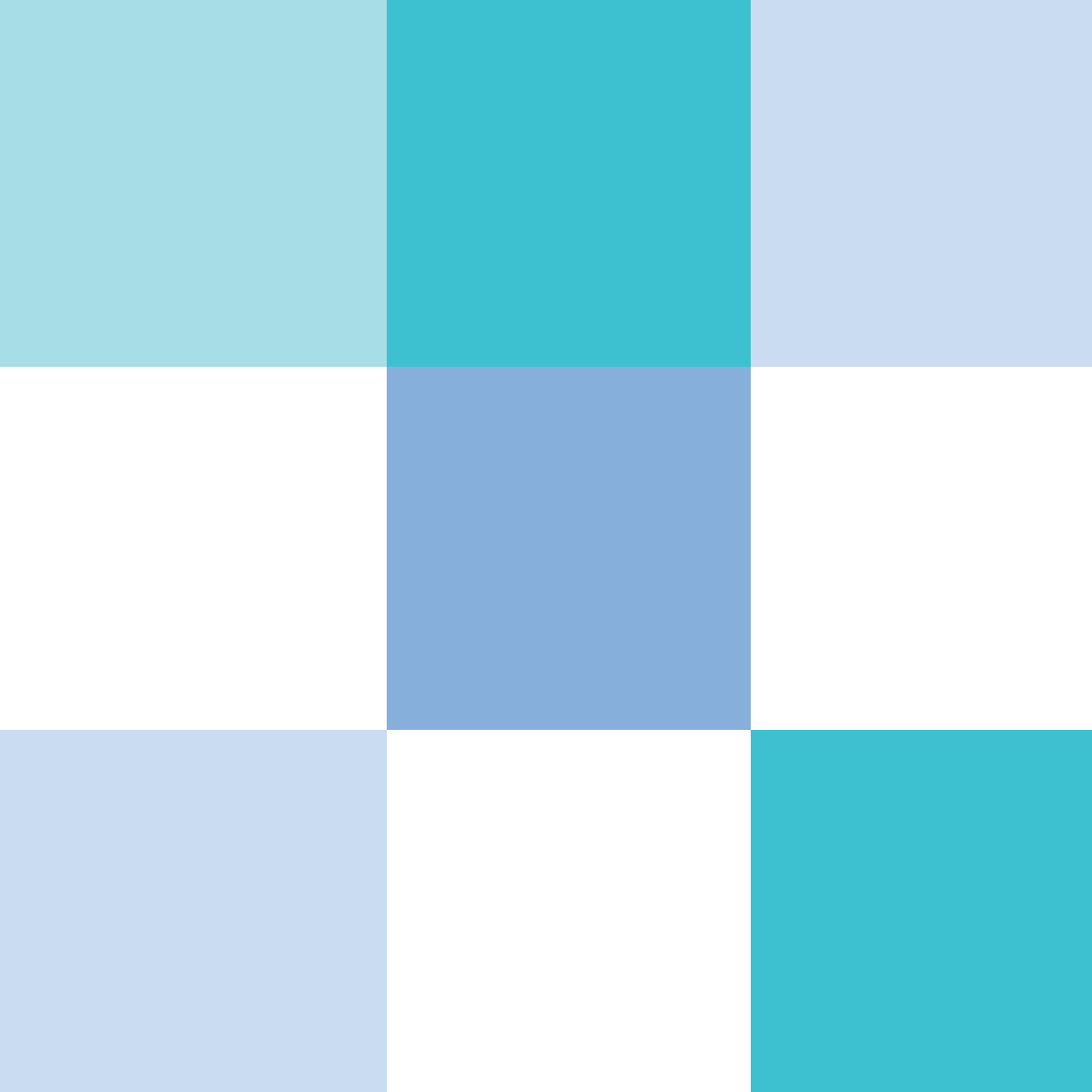
CO_2 Solutions

QUICK REFERENCE GUIDE

RESPIRONICS

Envisioning tomorrow. Improving today.



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A Quick Guide to Mainstream & Sidestream Capnography Standards and Guidelines for CO_2 Monitoring

Why measure CO_2?

Capnography has been shown to be effective in the early detection of adverse respiratory events. Capnography provides a rapid and reliable method that may detect life-threatening conditions and helps avoid potentially irreversible patient injury. Capnography provides clinicians instantaneous feedback that the endotracheal tube used for mechanical ventilation is correctly positioned to deliver gas to the lungs and that it remains in place throughout any manipulation of the patient. Capnography is the most rapid indicator of missed intubations, kinked sampling lines or accidental extubation, helping to assure reliable patient safety. CO_2 monitoring is becoming a global standard of care for patient safety.[1,2] The American Society of Anesthesiologists (ASA), the American Association for Respiratory Care (AARC), and the American Hospital Association (AHA) have all adopted standards and guidelines for CO_2 monitoring. The American Society of Anesthesiologists (ASA) - Standards for Basic Anesthetic Monitoring, updated in 2010, now notes that the adequacy of ventilation during both general anesthesia and moderate and deep sedation shall be continually evaluated by both "qualitative clinical signs" and monitoring of expired carbon dioxide.[1] This safety improvement, long in the making, identifies the monitoring of expired carbon dioxide as a means to assessing the adequacy of ventilation and has been implemented in part due to the risks associated with procedural sedation.[2] The 2010 update of the American Heart Association's (AHA) adult advanced cardiovascular life support (ACLS) included a number of important changes to the 2005 ACLS guidelines. In addition to changes to the cardiac arrest algorithms and changes to

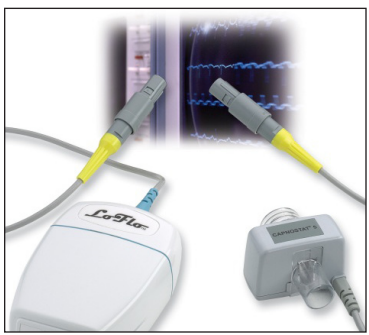
drugs for therapies, this update includes the new recommendations for "continuous quantitative waveform capnography... for confirmation and monitoring of endotracheal tube placement" as well as a discussion of the potential value of end-tidal CO_2 as an indicator of the return of spontaneous circulation (ROSC) and as a tool to optimize CPR quality.[3] Many states, such as Florida and New York have laws mandating that every ambulance be equipped with a CO_2 measurement device. Europe has also adopted CO_2 monitoring in some countries as a result of societal standards and in other countries as a result of individual country law. Due to Capnography's usefulness as a safety monitor and its ease of use, the utilization of Capnography is spreading similarly to the way pulse oximetry did. Fueling the increase in the use of capnography is miniaturization and technology advancements. Capnographs and capnometers today are small, very robust, and easy to use. This allows easy integration into patient monitors, defibrillators and ventilators, making capnography simple and inexpensive for the clinician. With Respironics technology, the ease of use is enhanced because of the "CO_2nnect & Go Capnography" capabilities.

Flexible CO_2 Monitoring Solutions

CO_2nnect & Go CO_2 Technology

CO_2nnect & Go CO_2 Mainstream and Sidestream $ETCO_2$ monitoring allows the customer to match the appropriate technology to the needs of a specific patient by switching easily between Mainstream and Sidestream monitoring:

Select the LoFlo sidestream sensor for monitoring non-intubated patients



Choose the CAPNOSTAT mainstream sensor for optimal performance in monitoring intubated patients

SIDESTREAM SENSOR

LoFlo Sensor Supplies

MAINSTREAM SENSOR

Mainstream Sensor Adapters

The Right Solution

MAINSTREAM SENSOR

CAPNOSTAT Sensor for Intubated Patients

- **Small, durable,** and **lightweight** mainstream CO_2 sensor provides accurate and reliable monitoring for all intubated patients from neonates to adults
- No calibration required
- Fast, accurate on airway measurement

SIDESTREAM SENSOR

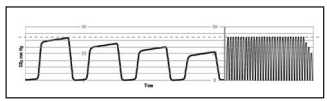
LoFlo Sensor for Non-Intubated or Intubated Patients

- A **flexible** and **compact** CO_2 sensor that provides consistent and reliable CO_2 monitoring of adult, pediatric and neonatal patients
- No calibration required
- 50 ml/minute sampling rate

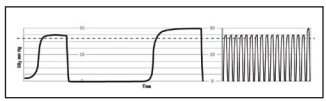
The Many Uses of Capnography

Ventilator Management

- Assists in determining when to intubate or extubate
- Verification of ET tube placement
- Alerts if accidental extubation occurs
- On-going airway management
- Initial setup, monitoring and weaning from ventilator
- Ventilator disconnect detection
- Assists in determining hyper & hypo ventilation
- Assists in determining deadspace (A-a CO_2 Gradient)



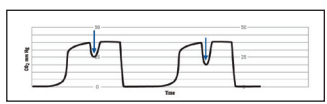
Hyperventilation



Hypoventilation

Monitoring & Diagnostic

- Waveform analysis – breathing pattern assessment
- Visualize changes in ventilatory pattern
- Assessment of patient/ventilator synchrony
- Monitors for over-sedation
- Verification of target $PaCO_2$ in head trauma patients
- Assists in determining loss of airway control
- Assessment of neuromuscular blockade drugs
- Evaluation of bronchodilator therapy
- Useful in asthma management, especially in the ED
- Effectiveness of chest compressions during CPR
- Verification of ventilation during transport



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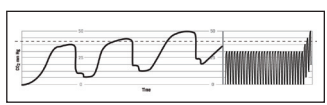
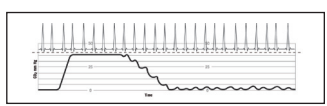
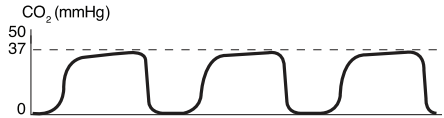


Faulty Exhalation Valve



Cardiogenic Oscillations

Monitoring with Mainstream vs. Sidestream CO_2 Sensors



Mainstream CO_2 Sensor	Sidestream CO_2 Sensor
• Most appropriate form of $ETCO_2$ monitoring for mechanically ventilated intubated patients[4,5]	• Used to monitor the $ETCO_2$ of non-intubated patients
• On-airway measurement – immediate response	• Sample diverted to measurement site from patient interface
• CO_2 sensor is located between the ET tube and the breathing circuit	• Cannulae available that sample CO_2 and deliver O_2 simultaneously
• Disposable and reusable adult/pediatric and infant/neonatal airway adapters	• Cannulae can be placed on patients under masks, such as oxygen delivery or CPAP masks

- The accuracy specifications of the CAPNOSTAT (mainstream sensor) and LoFlo (sidestream sensor) are the same
- Both monitor patient Respiratory Rate from 2 to 150 Breaths per minute
- Both measure $ETCO_2$ from 0 to 150 mmHg, 0 to 19.7% or 0 to 20 kPa
- The CAPNOSTAT sensor, LoFlo sensor, and all accessories used with them, are Latex free

What is a CO_2 Sensor Adapter Zero?

An "Adapter Zero" is a quick procedure that adjusts the CAPNOSTAT Mainstream sensor to the optical characteristics of each compatible Airway Adapter.

An "Adapter Zero" on the LoFlo sensor adjusts the Sidestream Sensor to the characteristics of each cannula, airway adapter or sample line.

What are the Guidelines to Performing an Adapter Zero?

Mainstream CO_2 Sensor

- Procedure is necessary with the first use of the CAPNOSTAT CO_2 sensor.
- Procedure is necessary when switching the Mainstream CAPNOSTAT sensor from one Airway Adapter type to another, such as when switching from a disposable to a reusable Airway Adapter.
- Zeroing is not required when switching from the same type of Airway Adapter, such as a disposable to a disposable Airway Adapter.
- Procedure is necessary when requested by the CO_2 monitor.
- Typical time for zero is 15-20 seconds.

Sidestream CO_2 Sensor

- Procedure is necessary with the first use of the LoFlo CO_2 sensor.
- A sample cell zero is not required when switching from one sampling accessory to another.
- Procedure is necessary when requested by the CO_2 monitor.
- Typical time for zero is 15-20 seconds.

In both cases, never zero the CAPNOSTAT sensor or LoFlo sensor without an adapter or sampling kit installed. When zeroing, always remove the adapter or cannula from the patient and keep all sources of CO_2 away from the sensor, including your own breath (CO_2 is heavier than air). Always refer to the user manual for complete instructions.

Key Questions & Answers
Frequently Asked Questions for Clinicians

Q:

How is CO_2 measured using the CAPNOSTAT mainstream sensor and the LoFlo sidestream sensor?

The mainstream and sidestream sensors measure the number of CO_2 particles in the exhaled gas using Infrared light. A broad band of light wavelengths are emitted by an Infrared source. The light is then focused by a lens and transmitted across the airway adapter (mainstream sensor) or the sample cell (sidestream sensor). CO_2 that passes through the light absorbs some of this light at a specific wavelength. The light is then focused through a filter set at the CO_2 absorption wavelength onto a detector. The amount of CO_2 in the airway is then determined by measuring the light that was absorbed.

Q:

When should I use the mainstream or the sidestream capnography sensor?

The mainstream and sidestream sensors are often confused as to when or why or how they should be used. Just consider that the end result is the same, which is monitoring $ETCO_2$. The sidestream sensor is commonly used in emergency medicine, procedural sedation, and the mainstream sensor is used on intubated patients.

Key Questions & Answers
Frequently Asked Questions for Clinicians

Q:

Which is more accurate? The Mainstream sensor or the Sidestream sensor?

The accuracy specifications between the CAPNOSTAT mainstream CO_2 sensor and the LoFlo sidestream CO_2 sensor are the same.[6,7] The difference between the two sensors is the application and display of the capnogram. The LoFlo sensor is typically used for non-intubated patients and the mainstream CAPNOSTAT sensor is used for intubated patients. The capnogram of the mainstream sensor is "crisper" as sidestream sensor sampling tends to round the capnogram as the gas sample is drawn down the tubing to be measured.

Q:

I thought that I could use the LoFlo sensor on intubated patients. Doesn't that make it a mainstream sensor?

Yes, you can use the LoFlo sensor on intubated patients. There are sampling kits that have an adapter to connect to an ET Tube. These may be used for short term ventilator care. In the presence of high humidity and/or secretions they are not as robust as the CAPNOSTAT sensor which is designed for use in these conditions. Using a sidestream sensor on an intubated patient does not make it a mainstream sensor, because a sidestream sensor removes a portion of the patient's breath, where as a mainstream sensor does not.

Q:

Can I use the LoFlo sensor on neonates?

Yes, you can. The LoFlo sensor samples at a rate of 50 ml/min. This is comparable or better than other sampling systems in the market. The LoFlo sensor is primarily used for nonintubated patients including neonates. The deadspace of the neonatal adapter is less than one ml, so it is acceptable for use on neonates. In the presence of high humidity, heavy secretions and/or very high respiratory rates, sidestream systems are not as robust as mainstream systems which are designed for use in these conditions. Mainstream technology provides a "crisper" capnogram. But, as with all monitoring technology, the decision to use it or not is always determined by the caregiver.

Q:

How long can I use the CAPNOSTAT sensor adapters and LoFlo sensor sampling kits?

You can use either the single patient use (SPU) disposable or the reusable adapters with the CAPNOSTAT. Regardless of the type, they are designed for long term use. The LoFlo sensor sampling kits are single patient use and the hours of use are as follows.

- LoFlo sensor sampling kits without Nafion can be used up to 12 hours.
- LoFlo sensor sampling kits with Nafion can be used up to 120 hours.

Key Questions & Answers
Frequently Asked Questions for Clinicians

Q:
What is the deadspace of your adapter?

CAPNOSTAT sensor adapters
(SPU or Reusable)

Pediatric/Adult = approximately 6 cc of deadspace

Infant/Neonatal = ≤ 1 cc of deadspace

LoFlo sensor sampling adapter kits
(SPU only)

Pediatric/Adult = approximately 7 cc of deadspace

Infant/Neonatal = ≤ 1 cc of deadspace

Q:
How do I determine which adapter to use?

CAPNOSTAT sensor adapters
(SPU or Reusable)

Pediatric/Adult = for use on ET Tube sizes > 4.0 mm

Infant/Neonatal = for use on ET Tube sizes ≤ 4.0 mm

LoFlo sensor sampling adapter kits
(SPU only)

Pediatric/Adult = for use on ET Tube sizes > 4.0 mm

Infant/Neonatal = for use on ET Tube sizes ≤ 4.0 mm

Q:

How should I position the CO_2 sensors?

For the CAPNOSTAT sensor, always keep the windows of the adapter in the vertical position. This will keep water and patient secretions from pooling on the windows. If the LoFlo sensor sampling adapter kit is used on an ET sampling line, always make sure that the tubing is pointing up. This will keep water and patient secretions from being drawn into the sampling line.

Q:

What is the best method for dealing with breathing circuit humidity?

The CAPNOSTAT mainstream sensor is heated close to body temperature to keep the adapter warm, which keeps water vapor from condensing on the windows. When the LoFlo sensor is connected to an ET Tube, the LoFlo sensor airway adapter kit with Nafion should be used to dry the sample which reduces the amount of condensed water in the sampling line. Water vapor passes harmlessly through the mainstream sensor adapter and the LoFlo sensor sampling line. The LoFlo sensor sampling kit also has a built in filter and water trap to collect any condensed water, keeping it from entering the LoFlo sensor sample cell.

Key Questions & Answers
Frequently Asked Questions for Clinicians

Q:

What side of the Heat/Moisture Exchange (HME) do I put the CAPNOSTAT sensor or LoFlo sensor airway adapter on?

The adapter can be placed on either side of the HME, but the recommended placement is as follows: the HME connects to the ET Tube adapter, the CAPNOSTAT sensor adapter connects to the HME, and the breathing circuit connects to the CAPNOSTAT sensor adapter. This will keep the adapter dry.

Q:

What is a normal range of $EtCO_2$?

The normal range for $ETCO_2$ is between 32 and 42 mmHg, which is roughly 5%. The CAPNOSTAT sensor and the LoFlo sensor measure the patient's CO_2 from 0 to 150 mmHg, or roughly 20%. They both measure respiration rates up to 150 breaths per minute. The accuracy range is as follows.

0 – 40 mmHg	± 2 mmHg
41 – 70 mmHg	± 5% of reading
71 – 100 mmHg	± 8% of reading
101 – 150 mmHg	± 10% of reading

Q:

Does the sensor compensate for Anesthetic agents and other gases?

Compensations are set in the host monitor by the user for oxygen, helium, nitrous oxide and anesthetic agents. Refer to your user manual for information on setting the compensations. Compensations are not needed for nitrogen or nitric oxide.

Q:

What is the Barometric Pressure used for and how do I set it?

Barometric Pressure is used to convert the numbers from pressure units of mmHg or kPa to percentages. It is also used in correcting for the effects of collision broadening in the gas sample especially in high concentrations. Refer to the user manual for instructions on how to set barometric pressure. Typically, the mean barometric pressure for your area is set.

Q:

How quickly will I see the Capnogram and numbers once I turn the monitor on?

On start up and after the sensor warms up, perform the airway adapter zero. After connecting to the patient, the CAPNOSTAT sensor will display the Capnogram within 15 seconds. The LoFlo sensor will display the waveform within 20 seconds. The $ETCO_2$ and Respiration Rate will display within 30 seconds or less. Remember, that if the sensor has been in a cold car all night, it will take longer to complete the warm up. Always let the sensor warm up to room temperature before use.

Key Questions & Answers
Frequently Asked Questions for Biomedical Engineers

Q:

What are the maintenance requirements for the CO_2 sensor?

There is no required routine maintenance or required field calibration for the CAPNOSTAT sensor or the LoFlo sensor. The reason no calibration is required is that the CAPNOSTAT sensor and the LoFlo sensor are calibrated at the factory and remain stable over time. The CAPNOSTAT sensor and the LoFlo sensor store calibration information and continually validate the stored information. If an error is recognized, the sensor will send an error message. The LoFlo sensor sampling pump is rated for 24,000 hours of continuous use, so there is not a need for replacement or adjustments. Some Biomeds set a yearly "maintenance check" of the sensors. The system is checked using a certified calibration gas. For the LoFlo sensor, a flow check can be performed using a calibrated flowmeter as desired.

Q:

What is a zero and when do I do this?

A zero is performed whenever a CAPNOSTAT sensor is connected to the monitor for the first time. Thereafter, perform a zero whenever a different style adapter is installed, such as when changing from reusable to single patient use or when the system displays a message to perform a zero. It is not necessary to perform a zero when changing types within the same adapter style. For example, when changing from a neonatal single patient use adapter to an adult single patient use adapter it is not necessary to perform a zero. Never zero the CAPNOSTAT sensor or the LoFlo sensor without an adapter or sampling kit installed. When zeroing, always keep all sources of CO_2 away from the sensor, including your own breath. The zero only takes 15 to 20 seconds.

Q:

Is a zero a calibration?

Not really. The function of a zero is to identify the optical characteristics (light transmission) of the adapter windows. The reusable adapter windows are sapphire and the single patient use adapters are plastic. The CAPNOSTAT sensor identifies the adapter by the adapter windows and this is done by performing a zero.

Q:

How can I get the regulator?

Please check with your customer service department. The regulator can be ordered from Respironics.

The Respironics part number is:
6081-00 Gas Regulator – Each

Q:

How do I clean the CAPNOSTAT sensor?

Unplug the sensor and let it cool to room temperature for 30 minutes before cleaning. Use only recommended cleaners and disinfectants listed below. Others may damage the product, shorten lifetime, or cause safety hazards. The manufacturer's warranty does not cover damage caused by using unapproved cleaners.

Use these general precautions:

- Always dilute cleaning agents according to the manufacturer's instructions or use the lowest possible concentration.
- Do not allow liquid to enter the case.
- Do not immerse any part of the sensor in liquid.
- Do not pour liquid on the sensor.

- Never use abrasive material (such as steel wool or silver polish).
- Do not autoclave, steam sterilize, or ultrasonically clean the sensor or its cable.
- Do not use bleach on electrical contacts or connectors

Cleaning the outside of the CAPNOSTAT sensor and its cable:

- Ensure the sensor is disconnected and cooled to room temperature for 30 minutes prior to cleaning.
- Use a cloth dampened with any of the approved cleaning agents listed below.
- Wipe down with a clean water-dampened cloth and dry before use. Ensure the CAPNOSTAT sensor windows are clean and dry before reuse.

The following cleaners have been tested and approved for cleaning the CAPNOSTAT sensor:

- Isopropyl alcohol 70%
- A 10% aqueous solution of chlorine bleach
- Steris Coverage® Spray HB
- Clinell Wipes®
- PDI Sani Cloth Bleach®
- PDI Super Sani Cloth AF®
- Speedy Clean™
- Tuffie™
- Tuffie 5™
- WIP Anios™

Q:

How do I clean the LoFlo sensor case, cable and the connector?

- Use a cloth dampened with isopropyl alchohol 70%, a 10% aqueous solution of sodium hypochlorite (bleach), a 2% gluteraldehyde solution, ammonia, mild soap or disinfectant spray cleaner such as Steris Coverage® Spray HB.
- Wipe down with a clean water-dampened cloth to rinse and dry before use. Make certain that the sensor windows are clean and dry before reuse.

Q:

What can I use to clean the CAPNOSTAT sensor reusable airway adapters?

Treat all reusable airway adapters in accordance with institutional protocol for single patient use items.

Clean by rinsing in a warm soapy solution followed by soaking in the following disinfectant:

- Isopropyl alcohol 70%
- 10% aqueous solution of sodium hypochlorite (bleach)
- gluteraldehyde 2.4% solution such as Cidex® or Steris System 1®

Rinse thoroughly with sterile water & dry

The reusable airway adapters may be sterilized using the methods listed below:

- Steam Autoclave – Reusable Adult Adapters Only
  121°C, 20 minutes
  134°C, 20 minutes
- Ethylene Oxide (ET)-1.5 hours exposure
- Soak in Cidex Plus solution for 10 hrs.
- Soak in Perasafe solution for 10 hrs.

Before reusing the adapter, ensure the windows are dry and residue free and that the adapter has not been damaged during handling or the cleaning/disinfecting process.

Q:

Through how many sterilization cycles can I use the reusable airway adapters?

The reusable adapters are intended to be capable of being cycled 100 times using the disinfecting and sterilization methods described above.

[1] American Society of Anesthesiologists (ASA). Basic Standards for Intraoperative Monitoring; 1999.

[2] Gravenstein JS, Jaffe MB, Paulus DA(eds). Capnography: Clinical Aspects: Cambridge University Press: Cambridge, UK, 441 pp, 2004.

[3] ASA Standards for Basic Anesthetic Monitoring, Standards and Practice Parameters (Approved by the ASA House of Delegates on October 21, 1986, and last amended on October 20, 2010 with an effective date of July 1, 2011) - viewed 7-18-12 (ww.asahq.org)

[4] "No Patient Shall be Harmed by Opioid-Induced Respiratory Depression", APSF, Fall 2011, The Official Journal of the Anesthesia Patient Safety Foundation.

[5] Michael B. Jaffe, PhD, "Mainstream or Sidestream Capnography?" Respironics Novametrix, Inc. Wallingford, CT. Page 1-13, 2012.

[6] CAPNOSTAT Mainstream CO_2 Sensor, Respironics 2010.

[7] LoFlo Sidestream CO_2 Sensor, Respironics, 2010.

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